CHANGING WHAT'S POSSIBLE

Data Centers

Technology to Market Perspectives

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"Cooling Compute Systems Efficiently, Anytime, Anywhere" Workshop

December 14th 2021

Datacenter Classification

Hyperscale

- Will be able to **significantly reduce costs of operating center** and add additional servers
- Additional power will be directed from cooling to computing power, resulting in more cloud capabilities

Co-Location

- More efficient cooling processes result in cheaper operating costs, **resulting in higher margins**
- Additional computing power allows for **additional renting capacity**

Edge

- Better cooling will empower edge data centers to be in **more locations and more renting capacity**
- Reduced cooling offers wider applications and adoption of edge data centers

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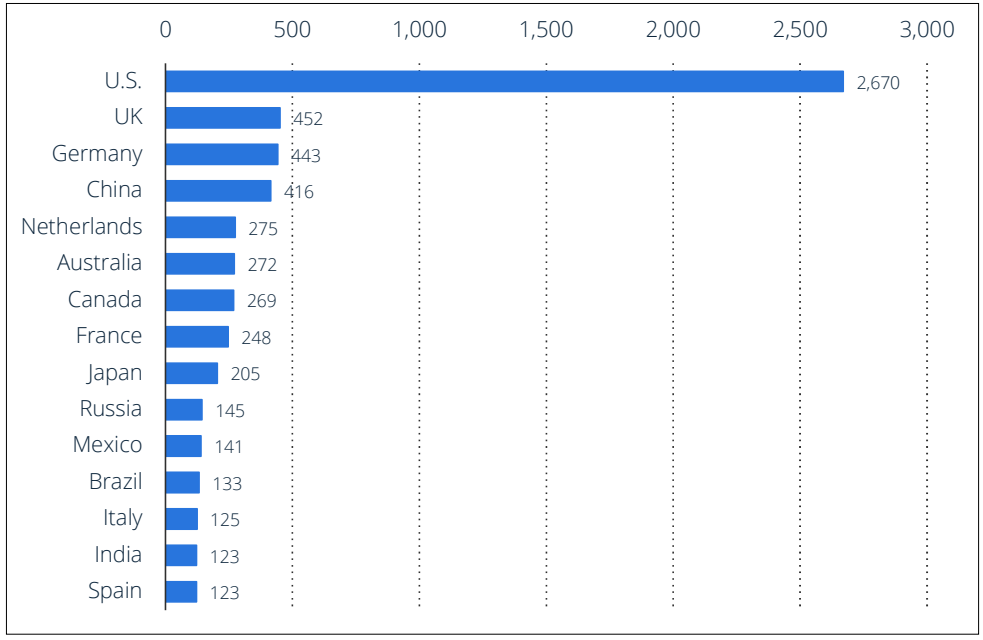
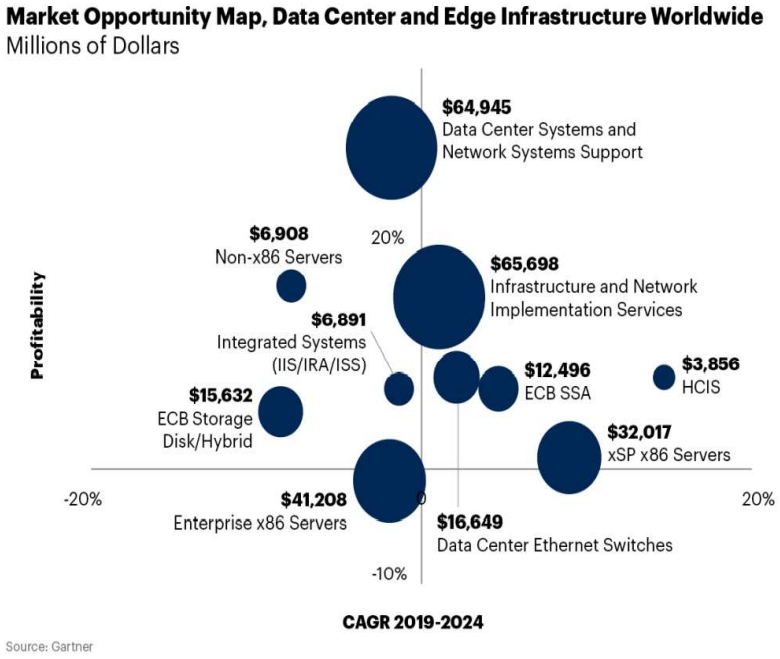
Forecasted Market Growth

- Significant growth in domestic and international markets

Number of data centers worldwide in 2021, by country



Source(s): Cloudscene; ID 1228433



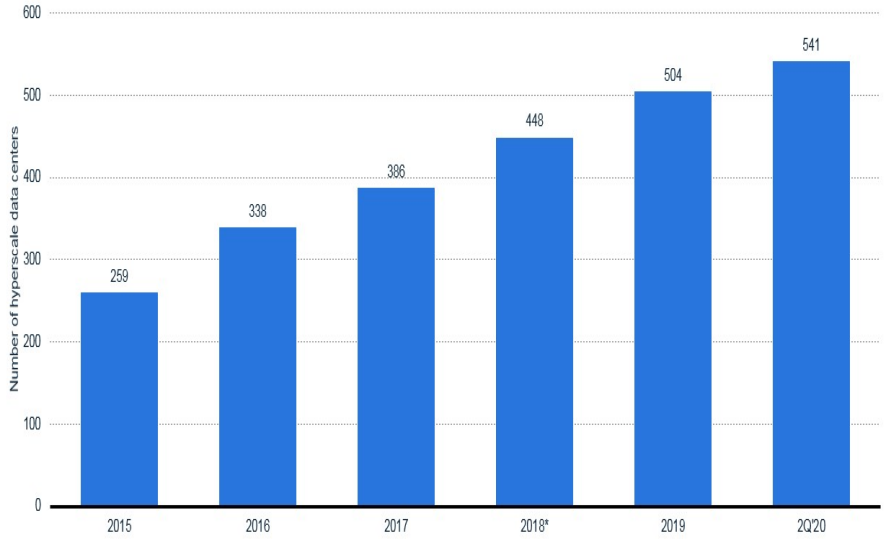
Hyperscale Trends

- Robust growth driven by tech giants

Growth Trends

Number of hyperscale data centers worldwide from 2015 to 2020

Global figure of hyperscale data centers 2015-2020

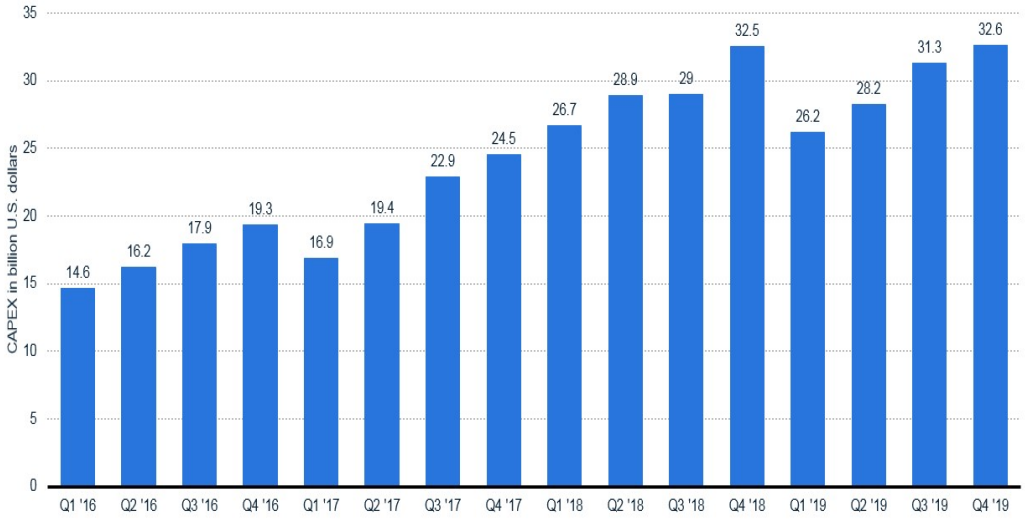


Note: Worldwide; 2015 to 2020
Further information regarding this statistic can be found on page 55.
Source(s): Cisco Systems; Synergy Research Group; ID 633826

Capital Expenditures

Global hyperscale operators capital expenditure (CAPEX) from 1st quarter of 2016 to 4th quarter of 2019 (in billion U.S. dollars)

Global hyperscale operators CAPEX Q1 2016 - Q4 2019



Note: Worldwide; Q1 2016 to Q4 2019
Further information regarding this statistic can be found on page 56.
Source(s): Synergy Research Group; Statista estimates; ID 1109393

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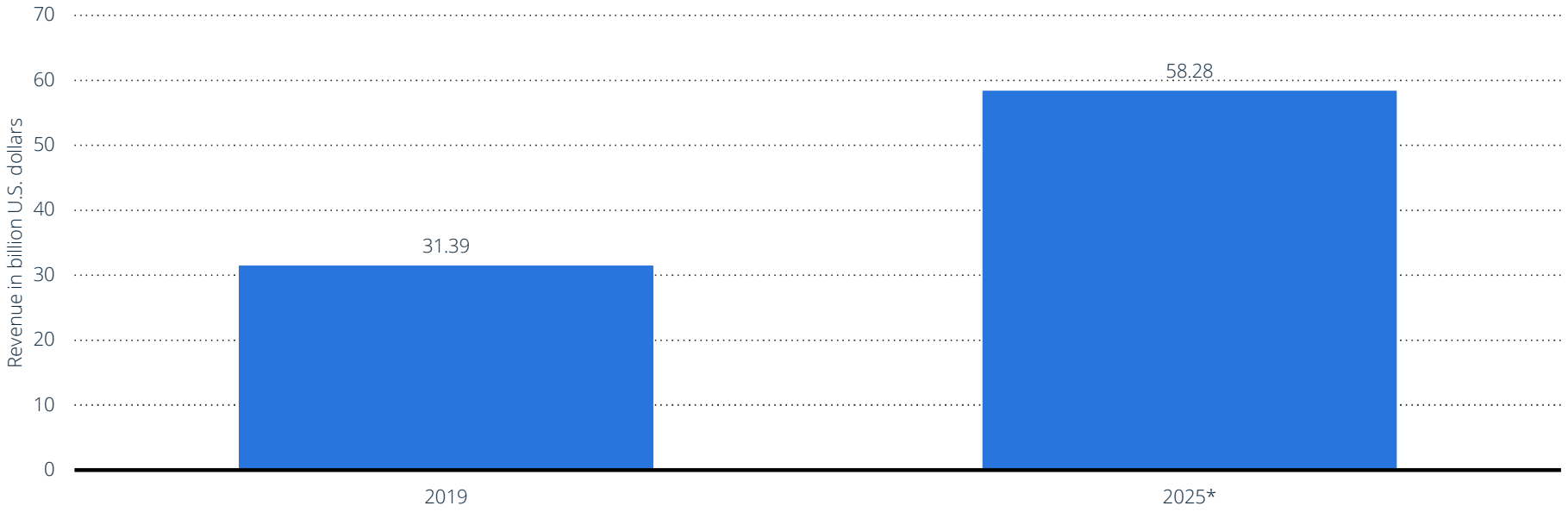
Colocation Trends

- The “real estate” play

Colocation data center market revenue worldwide in 2019 and 2025 (in billion U.S. dollars)

Global colocation data center market revenue 2019 & 2025



Source(s): Vertiv; ID 496373

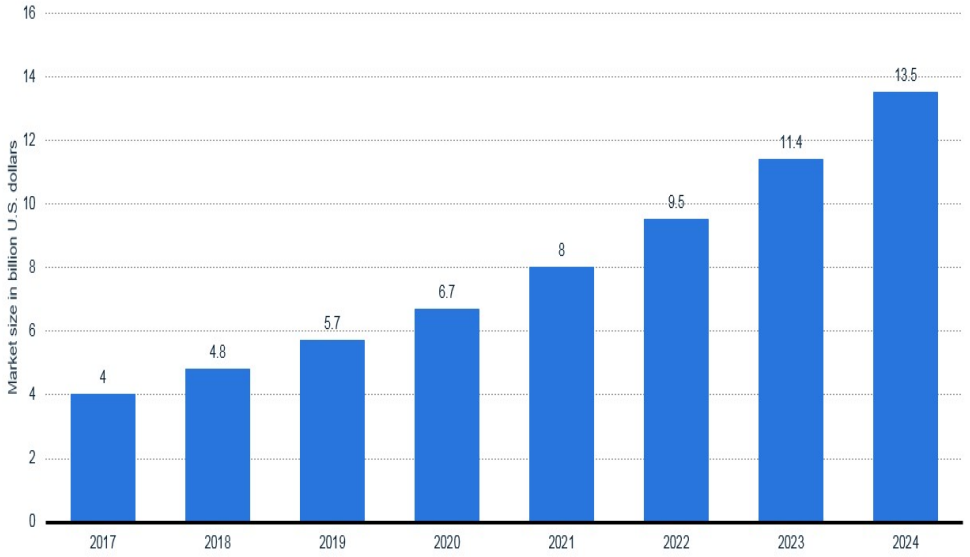
Edge Trends

- The “IOT/Connectivity” play

Growth Trends

Edge data center market size worldwide from 2017 to 2024 (in billion U.S. dollars)

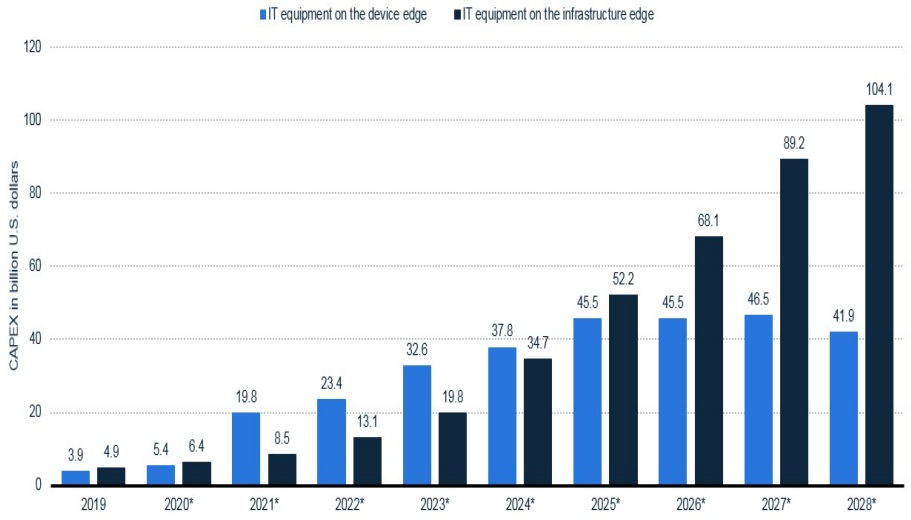
Global edge data center market size 2017-2024



Capital Expenditures

Edge computing device and infrastructure capital expenditure (CAPEX) worldwide from 2019 to 2028 (in billion U.S. dollars)

Global CAPEX of edge computing devices and infrastructure 2019-2028



Source: Statista

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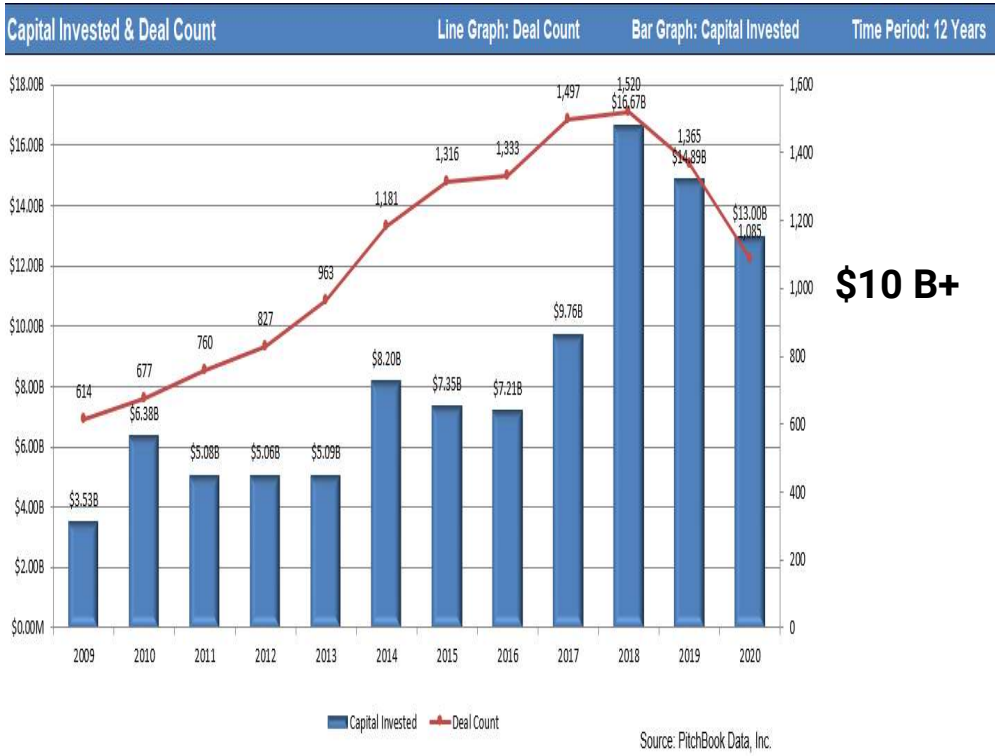
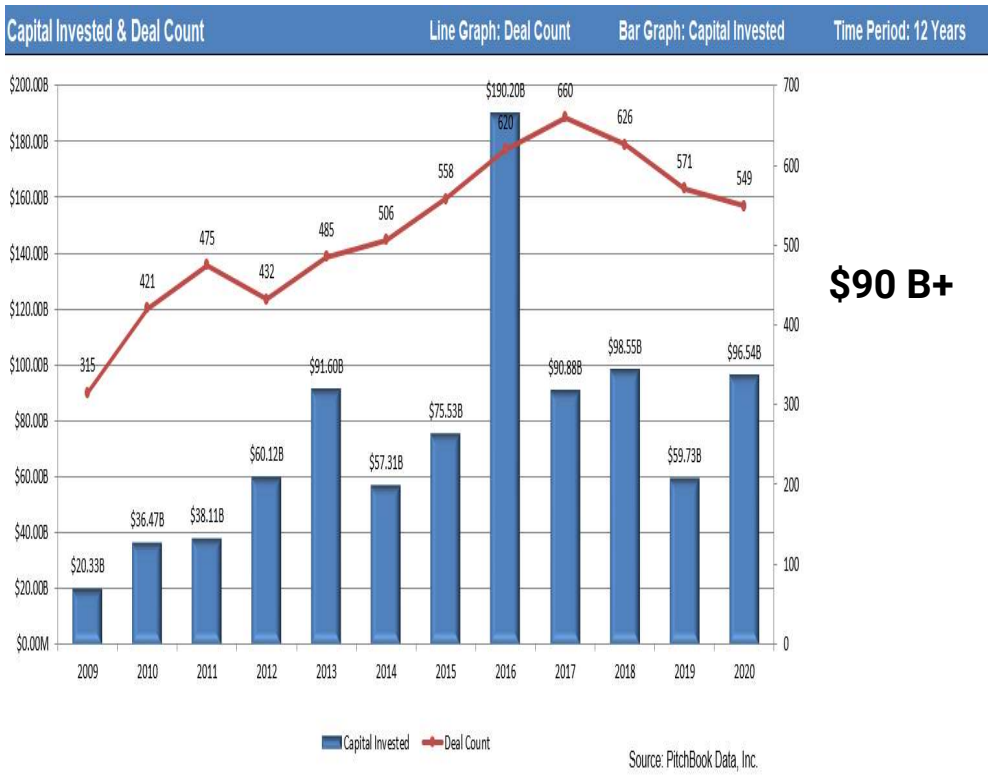
Market Basics – Investment Trends

Venture Capital Investments



$10 B+

Private Equity Investments



$90 B+

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Business Model Types

Wholesale vs Retail Data Centre Business Model

	Wholesale data centre	Retail data centre
Target customers	Cloud service provider, wholesale colocation and large organization	Small & medium enterprises, internet content companies, social media application developers
Contract term	5-10 years	1-3 years
Pricing	Lower (bandwidth cost is billed separately to customers, electricity in some cases)	Higher (value-added services, electricity and bandwidth are standardized and packaged with cabinet space)
Power	Min 500kw	Min 1 cabinet 4-5kw
PUE	Lower, usually below 1.7	Higher, usually between 1.8-2.5
Value-added service	Physical security (enhanced control), uninterrupted power supply (UPS) and air conditioning	Physical security, uninterrupted power supply (UPS), air conditioning, telecom and proximity services
Return (Target ROC)	12% - 15%	25% - 35%
# of customers	3-10 customers	100+ customers
Company	GDS, AtHub, Baosight, Digital Reality	Sinnet, 21Vianet, Equinix, QTS

Source: Goldman Sachs Research, April 2020

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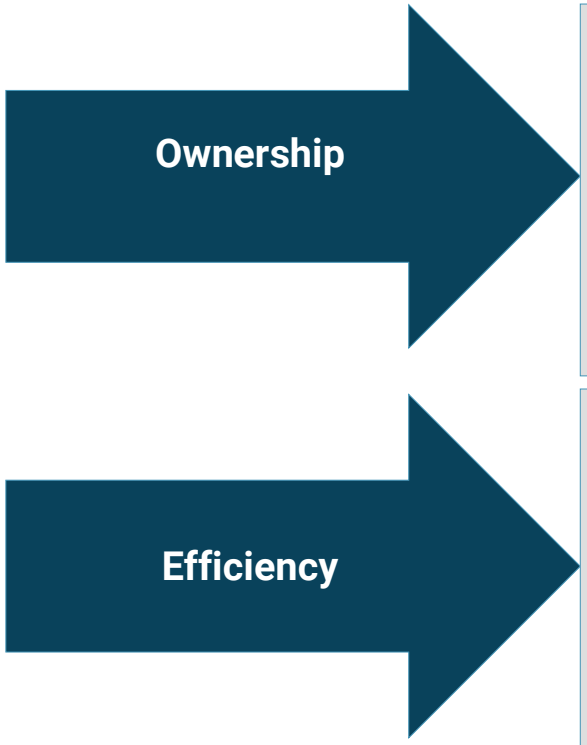
Why Revenue Structure Matters



- Revenue structure **dictates behavior in the data center energy consumption space**
- Companies are incentivized to reduce environmental footprint **in order to reduce costs and increase revenue**

- From 2010-2018, the **amount of computing performed by data centers increased by 550%**, however the amount of **energy used increased by only 6%**
- **New technologies and the desire to keep costs low have drastically improved energy efficiency**, but there is still a long way to go

Revenue Structure -> Incentivizes Behavior

How is More Computing Power Utilized?

Hyperscale	Co-Location/Edge
   	   
Cost Cutting **Additional Cloud Capabilities**	**Additional Renting Capacity**

Techno-Economic Analysis Model Executive Summary

- **Hyperscale and Co-Location/Edge Use Additional Computational Power Differently**
  - Hyperscale uses power savings from cooling efficiency to lower OpEx and additional computational capabilities
  - Co-location/Edge uses power savings from cooling efficiency for additive revenue streams and additional usages

- **CapEx Most Expensive Data Center Expense**
  - Capital Expenditures take a significant time to payback and most investors need a quick return (~7 years)

- **Data Centers Are High-Margin and Lowering OpEx Can Be Very Lucrative**
  - Data Centers operate between ~5-30% margin and any way to lower the operating expenses is very desirable to operators

Techno-Economic Analysis Model - DCF

All amounts in USD

Assumptions

General Assumptions						
Currency			USD	**Cost Savings**		
First operational year			2021	Cost per Unit of Cooling	USD	$ 5,000.00
Setup year			2020	Total Units of Cooling Saved	kWh	$ 28.00
Forecast period	Years		30	**Total Cost Savings of Cooling**	USD	$ 140,000.00
				Cost per Unit of Electricity	USD	$ 100.00
				Total Units of Cooling Saved	kWh	$ 30,000.00
				Total Cost Savings of Electricity	USD	$ 3,000,000.00
				Cost per Unit of Computing	USD	$ 1,000.00
				Total Units of Computing Saved	kWh	$ 3,500.00
				Total Cost Savings of Computing	USD	$ 3,500,000.00
Other				**Interest, Taxes and Dividends**		
Depreciation period (years)	Years		15	Interest rate Term loan A	%	5%
Yearly capital expenditures (CAPEX)	USD	$	500,000.00	Tax rate	%	28%
				Dividend of Net Income	%	100%
Days Receivables	Days Sales		30	Bank Loan Duration	Years	20
Days Inventory			30			
Days Payables			30			
Other current assets	Days Sales		2	**Project Financing**		
Other current liabilities	Days Sales		1	Equity	%	30%
				Financial Debt	%	70%
Discount rate	%		10.0%	**Total**	**%**	**100%**
Capital Expenditures				**Sources of Financing**		
Cooling Capex			615,935.00			
Network Costs	USD		1,000,000.00			
Total CapEx	**USD**	**$**	**1,615,935.00**	Equity	USD	2,189,750
Operational Expenditures						
Air Cooled OpEx	USD	$	183,230.00			
Cooling (Total)	USD	$	500,000.00	Loan	USD	5,109,416
Miscellaneous Expenses (Employees, Licensures, etc.)		$	5,000,000.00			
Total OpEx	**USD**	**$**	**5,683,230.00**			
Total	**USD**	**$**	**7,299,165.00**	**Total**	**USD**	**7,299,165**

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Techno-Economic Analysis Model - DCF

All amounts in USD

Financial Overview

Project Lifetime		2021 1 Year	2021-2026 5 Years	2021-2051 30 Years
Revenues	USD	20,000,000	102,020,100	695,697,831
COGS	USD	(12,000,000)	(61,212,060)	(417,418,698)
OPEX	USD	(5,683,230)	(28,990,185)	(197,690,539)
EBITDA	USD	2,316,770	11,817,855	80,588,593
Margin	%	11.6%	11.6%	11.6%
Taxes	USD	(512,445)	(2,533,473)	(17,089,323)
Change in NWC	USD	(1,698,630)	(1,767,601)	(2,266,829)
CAPEX	USD	(500,000)	(2,550,503)	(24,691,611)
FCFF	USD	(394,305)	4,966,279	36,540,831

All amounts in USD

Key Performance Indicators

Project Metrics		
Project costs	USD	7,299,165
Discount rate	%	10.0%
NPV	USD	4,262,574
PayPack Period (FCFF)	Years	7
Project IRR	%	15.8%
Equity IRR	%	25.8%
Balance Sheet Check		(0.0)

Financing		
Equity financing	%	30%
Debt Financing	%	70%
Ratios		
EBITDA Margin	Year 1	11.6%
ROIC	Year 1	24.3%
ROE	Year 1	70.0%
Financial Leverage		
DSCR	Min.	-0.78x
Financial Debt / EBITDA	Max.	2.10x

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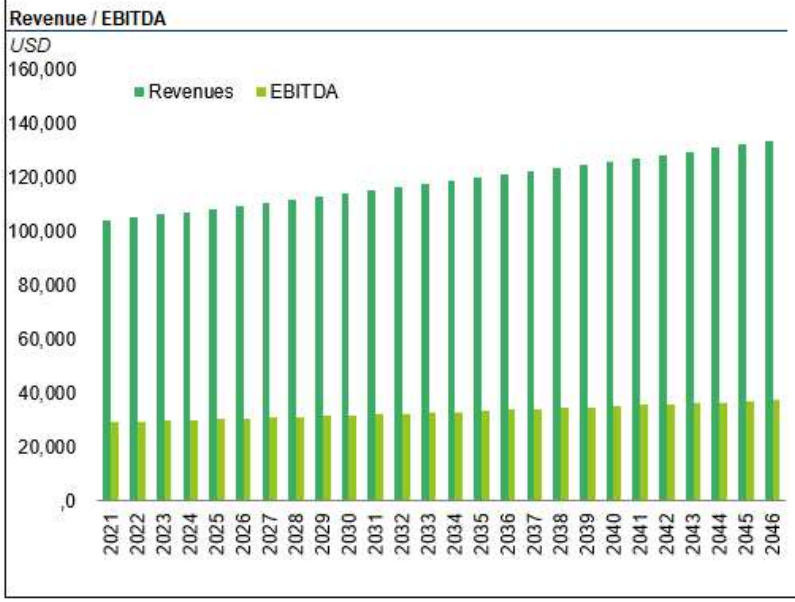
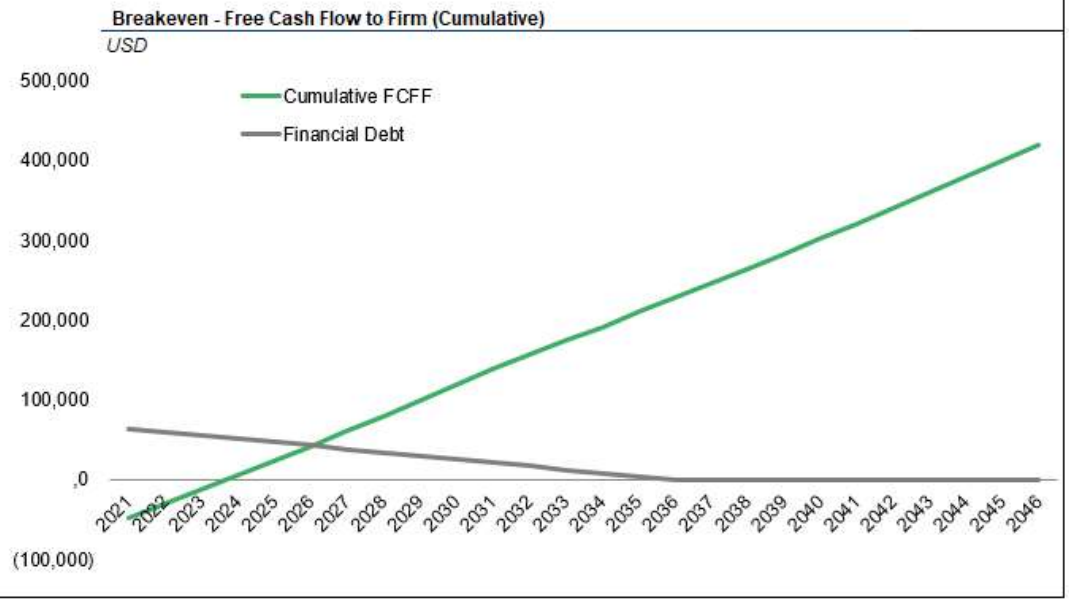
Techno-Economic Analysis Model - DCF

IRR Project Finance 8/4/2021

All amounts in USD

Executive Summary





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Next Steps

- As part of this program, ARPA-E intends to create a single TEA platform that could be utilized to evaluate the benefits of competing technology options in various workstreams

- Possible support required from EPCs, national labs etc. to develop this independent model that could eventually be open sourced (e.g. NREL System Advisor Model)

U.S. DEPARTMENT OF ENERGY

https://arpa-e.energy.gov